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ABSTRACT

In the first part of this cost-analysis of National Science Foundation (NSF) institutes, the financing of the University of Wyoming Portal School Project is described and expenditures and outcomes of the program for the years 1971-1974 are estimated. The average cost of the project to the NSF was $1.30 per teacher participation hour. The cost of this project was compared to that of four other NSF programs. In the second part of this report, the cost-effectiveness of various NSF summer institutes for teachers was determined based on teacher and student gains in science test scores. The average cost of a summer institute for physics teachers was $58.50 per teacher percentage point gain in test score. The cost-effectiveness of another summer institute in physics is given on the basis of increase in student performance on three tests. (BB)

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Cost-Analysis of NSF Sponsored Programs: An Exploratory Study

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Introduction

> Costs are shadowy figures hovering in the background of evaluation, spectres that come to haunt those who tried to ignore them, Janus-faced figures more elusive than the most ghostly of the mental entities to which the hard-nosed empiricist objects in the scientific context, and yet the very substance of the hard-nosed empiricist's position in the management area. (Scriven, 1973)

In this rather eloquent sentence, Scriven has emphasized two crucial points concerning cost-analysis in educational evaluation. First, program costs are an important aspect of evaluation. The evaluator who ignores program costs is omitting an important component of program evaluation. The decision-maker who neglects to consider program costs is basing his decisions on only partial information and, consequently, risks the possibility of errors of judgment.

The second point Scriven makes concerns the extreme difficulty of both obtaining cost data and defining costs. Costs are generally classified as direct or indirect. Direct costs include such things as salaries, tuition, and materials costs. These are not as difficult to define as to obtain. Indirect costs are a bit more elusive. They are difficult to both define and obtain. Overhead and preparation time are indirect costs. If a teacher decides not to take a summer job in order to attend a workshop, this is an indirect cost. If an institute attendee develops an ulcer attributable to

participation in the program, this, too, is an indirect cost. In view of the problems with measuring indirect costs, this study is concerned mainly with direct costs.

The present study is a two-part exploration in cost-analysis of National Science Foundation (NSF) sponsored programs. The two parts represent different aspects of "effectiveness." Part I is concerned with participation and exposure costs. "Participation cost" for teachers is the cost of providing one teacher with the opportunity to attend an NSF sponsored program. Student "exposure cost" is the cost for one student to receive the benefit of a teacher's attendance.

The second part of the study is concerned with determining the cost of various outcome measures for teachers participating in NSF sponsored programs and for students who are affected by these teachers. These measures are perhaps more crucial to a cost-analysis than participation and exposure costs. It is one problem to determine the cost of providing a teacher with the opportunity to attend a workshop or an institute. It is an altogether different issue to determine if these opportunities are producing a positive change in the teachers and the teachers' students, and if so, what these gains are costing. Various NSF sponsored summer institutes will be examined in terms of these gains.

These examples by no means exhaust effectiveness measures. A comprehensive, long-ranged cost-analysis would take into account such things as occupational choice of program participants, increased earnings, benefit to the national interest, etc. But these measures are beyond both the scope and interest of this study.

PART I: PARTICIPATION AND EXPOSURE COSTS

The Portal School Concept

The Portal School Project of the University of Wyoming was chosen as a case study for this cost-analysis for two reasons. First, the project is an innovative example of NSF sponsored programs. Secondly, estimates of both cost and effectiveness measures were available.

The Portal School Project was a part of one of five programs to receive funding under the NSF Comprehensive Grants Program in 1971. For those interested in a detailed portrayal of the Portal Schools, see Evaluation of the Portal School Program (Bracht et. al., 1973). The purpose of the Portal School program is to assist schools in the Wyoming region to develop their capacity for self-improvement in science and mathematics education. The program is operated by the Science and Mathematics Teaching Center (SMTC) at the University of Wyoming. The Center is staffed by the College of Arts and Sciences and the College of Education. The SMTC is the focal point of both science and mathematics educational research and teacher training.

Three steps exist in the formulation and implementation of a Portal School. The first step involves assessing the needs of and formulating objectives for participating school districts. Representatives from the district meet with the coordinator of the Portal School program. If the decision is made to implement a Portal School, the coordinator also assists in the selection of the Portal leader(s).

The second phase concerns the training of these leaders. Generally, prospective leaders are brought to the University of Wyoming campus during the summer to attend a minitute. A minitute follows a generally unstructured

environment. Prospective Portal leaders, being aware of the specific needs and general Portal School plan of the district, are informed about available materials, facilities and faculty, and permitted to explore alternative programs. The minitute lasts anywhere from one to six weeks. The end result is a detailed work plan for the particular Portal School.

After the workshop plans have been approved and the leader(s) certified, the leader(s) return to the school district to conduct the Portal School. Portal School workshops are conducted at one of three levels; exploration workshop partfcipants may examine one or more curricula; implementation workshops prepare teachers to implement a specific curriculum and; creative expansion workshops allow teachers to modify and expand upon curricula.

Each workshop carries one, two or three semester credits from the University depending upon whether the 150 minute sessions are held seven, eleven or seventeen times, respectively. The duration of the workshops is determined by the needs of the particular Portal School.

Financing the Portal School

Introduction

In the evaluation report (Bracht et. al., 1973), sources of Portal School support and types of expenditures were described in detail. Figure 1, presented below, is a modified version of Figure 1 (p. 45) taken from that report. The present study will expand this effort by providing cost figures for a three year period, 1971 to 1974. The sources of support (i.e., financial resources) represented in Figure 1 are described below.

Figure 1

Matrix of Expenditures and Financial Resources in the University of Wyoming's Portal School

Expenditures	Financial Resources: NSF	University	Local Contributions
A. Field Coordination	X		
B. Development of University Services		X	X
C. Training Portal Leaders	X		X
D. Salary for Portal Leaders			X
E. Curriculum Materials			X

NSF Contributions

NSF funds are used mainly to train Portal leaders. Other uses are the salary and travel expenses of the coordinator. The latter is used in setting up Portal Schools. Cost figures were provided by the SMTC. The figures were taken from the financial reports after completion of the project.

NSF funds were granted to support science workshops. No money went directly for math education. However, a percentage of the tuition paid by science participants reverts back to the SMTC (see "Local Contributions" on next page). Some of this money is used to initiate workshops for mathematics teachers. In essence, then, NSF money lays the foundation for both science and mathematics workshops. Both science and math participation hours (defined below) are therefore included in the analysis.

University Expenses

The services of the SMTC are essential in the operation of the Portal School Program. The SMTC provides staff, facilities and materials for the training of Portal leaders. Occasionally the Center lends materials for use in workshops. The figures for both university expenses and local contributions are estimates provided by the SMTC of financial contributions to the entire comprehensive program. Most of the money, however, went to the Portal School Program. University figures include released time for faculty and staff as well as small sums for materials. Because only a small portion was used for materials, the entire sum was distributed proportionally in the calculation between science and math participation hours. The feeling was expressed, however, that slightly more money was spent on math materials. The latter had to be constructed while science materials were generally packaged and obtained economically from the distributors.

Local Contributions

The operations of the Portal Schools are greatly dependent upon local district support. For example, the university charges a tuition fee at the rate of $20 per semester credit for any Portal School participant. The SMTC estimates that over half of the tuition fees are paid by the school districts. The other half is paid by the teachers. Tuition received by the SMTC is distributed as follows:

30% stipends for Portal leaders

30% held in reserve for school systems to purchase additional Portal School services

40% revolving fund of the SMTC

Tuition is not the only expense incurred by the school districts. They must provide faciilities for workshops as well as materials, texts, etc. Estimates of school district expenses were provided by the SMTC. These figures were obtained from a sample of letters estimating expenses from participating schools. These estimates are direct costs and include such things as travel for participants, kits, texts and other materials.

Science teachers participating in Portal School workshops in 1971-72 and 1972-73 were sampled to obtain estimates of expenses that they themselves were required to pay. The most commonly listed expense was tuition. Estimates of tuition are included above. Other expenses included minimal travel, texts, etc. Much of this was reimbursed by the district. In essence then, reported, non-reimbursed teacher expenses are negligible and are not included in this report.

Data Collection

Cost figures for the sources of financial contributions described above are presented in Table 1. As mentioned above, sources and estimates of these

figures were obtained from the staff of the SMTC. Explanation of some of the other figures listed in the table is necessary at this point.

Figures for workshop participants are also listed in Table 1. The figures presented have been rounded. Because of rounding error, the ambitious reader who decides to recalculate some of the measures may derive slightly different figures. A teacher semester refers to one teacher participating in one workshop regardless of the number of credits received and regardless of the number of other workshops this hypothetical teacher attended. Participation hours refers to length, in hours, of the workshops (i.e., length of the session x number of sessions). Minitute attendees are not included in the estimates.

Workshop participant data data were compiled from various sources. Some of the data was gathered personally by the author. Additional data were sent by the SMTC staff at the request of the author. Still other data were obtained in conjunction with another study being conducted at the Minnesota Research and Evaluation Project (MREP). In addition, a partial list of workshop participation figures had been compiled by the SMTC staff for their own purposes.

Because the university records were not kept in anticipation of this type of study, complete accuracy of figures is difficult to obtain. Where duplicate data were available from both the SMTC and the author, cross-checks were made. Various data categories for 1971-73 (e.g., 1971-72 elementary math) were discrepant from zero to approximately ten percent. The only large discrepancy appeared between the duplicate figures for 1973-74. The SMTC estimated 1,564 total teacher semesters (sub-category data estimates were not available), while the author estimated 1,765 teacher semesters. These data were gathered as an afterthought to the original two

Table 1

Estimates of Expenditures and Outcomes for the Portal School Program

	Year of Program			
	1971-72	1972-73	1973-74	3-Year Totals/ Averages
Number of Science Teacher Semesters	985	719	939	2643
Number of Math Teacher Semesters	584	1187	826	2597
Average Participation Hours - Science	39	40*	27	35
Average Participation Hours - Math	28	27	26	27
NSF Funds	$ 52,022	$ 88,030	$ 76,960	$217,012
Estimated University Funds	$ 61,313	$ 71,339	$119,275	$251,927
Estimated Local Contributions	$ 82,300	$137,900	$194,980	$415,180
Total Costs	$195,635	$297,269	$391,215	$884,119
Cost/Teacher Participation Hour - NSF	$ .90	$ 1.50	$ 1.60	$ 1.30
Cost/Teacher Participation Hour - Total	$ 3.60	$ 4.90	$ 8.20	$ 5.40
Usage Rate of Curricula (initial and subsequent years) 1971-72	46%			
1972-73	54%	48%		
1973-74	46%	47%	**	
1974-75	43%	38%	**	
Percentage Who Used Program at Least Once by 1974-75	64%	58%		
NSF Cost/Student (initial and subsequent years) 1971-72	$1.50			
1972-73	$ .70	$2.30		
1973-74	$ .50	$1.10	**	
1974-75	$ .40	$ .80	**	

*Estimate

**Data Not Available for 1973-74

year study, and circumstances did not permit as careful consideration of this year as the two previous years. The discrepancy rate in total teacher semesters for 1971-74 between the figures provided by the SMTC and those compiled by this author is less than three percent.

Figures for teacher participation are broken down by year and by discipline. The fiscal year used is June 1 to May 31; that is, in order to be included in the fiscal year, a workshop had to be virtually completed by May 31. This seemed to be the most natural break in the year according to the manner in which workshops were scheduled and avoided arbitrary decisions concerning which fiscal year to place various workshops.

Outcome Measures

Outcome measures are also listed in Table 1. The unit used to assess costs is teacher participation hour. That is, how much does it cost for one teacher to participate in an NSF sponsored program for one hour? This measure was selected over number of teachers because the latter proved misleading. For example, one math teacher might have participated in a one credit workshop while one science teacher participated in a three credit workshop. It hardly seems fair to estimate 17.5 hours of instruction as costing the same as 42.5/hours.

A secondary measure is cost per student exposed to a trained teacher. The number of students affected can be viewed in one of two ways. First, one can take the position that any teacher attending a Portal School subsequently will have some effect on all students (s)he encounters. Alternatively, it can be argued that students benefit only from direct application of part or all of a program studied at the Portal School. The cost per student figures provided in Table 1 are based on the latter assumption.

Cost per student estimates along with usage rate (explained below) were obtained from a questionnaire sent to a random sample of teachers who attended science workshops during 1971-73. These data were collected as part of another study being conducted at MREP. Data are not available on mathematics workshops nor on science workshops conducted during 1973-74.

Sampling of attendees was stratified according to year attended, type of curricula (i.e., elementary or secondary) and type of region (urban vs. rural). The latter distinction was not retained in the calculations; the population had been stratified in this manner for other purposes. Calculations performed both with and without the urban-rural stratification revealed no significant differences and, in most cases, no differences at all. Minitute attendees, respondents who had slipped into our sample by mistake (i.e., math workshop attendees along with people who had never attended a Portal School at all) and respondents who returned blank questionnaires for one reason or another, were eliminated from the sample. For the remaining respondents, estimates of number of students affected and program usage rate are based on attendees' reports of whether or not a program was studied at the Portal School and subsequently implemented in the classroom. Any program studied at the Portal School and implemented at any level of usage (i.e., supplementary, high or full) was included in the estimates. Where it was indicated that a teacher used a program but neglected to report the number of students, the mean number of students for users of that strata was substituted.

The cost per student estimates take into account that teachers often attended more than one workshop in a given year. Also taken into account is the fact that teachers occasionally attended workshops in successive years. Therefore, in calculating the number of students affected due to attendance

at 1972-73 workshops, any teacher who attended a workshop in 1971-72 was eliminated from the sample as his/her students were already included in the 1971-72 estimates. Essentially, then, 1971-72 was thought of in this paper as the starting point of the program; in reality, the program began in 1970.

Cost per student is provided for each successive year beginning with the year the workshop was held. The cost per student decreases each year because the initial (NSF) Portal School costs remain fixed, but teachers affect additional students each year.

Usage rate figures are also displayed in Table 1. Usage rate refers to what percentage of attendees (regardless of the number of workshops attended) used part or all of a Portal School program that year. Usage rates are provided for each successive year beginning with the year in which the workshop was scheduled. In addition, a cumulative usage rate, the percentage of workshop attendees who had ever used part or all of any program they studied at a Portal School at least once by 1974-75, is provided.

Some cautionary remarks must be imparted concerning the figures for both usage rate and cost per student. The figures represent this author's best estimate of program usage and exposure costs. However, these estimates were obtained from self-reports of attendees concerning whether or not they had studied a particular curriculum, subsequently implemented the curriculum to any degree, and how many of their students were "exposed" to the curriculum. Anyone who has worked with this type of data is aware of the fallibility of the human memory. For example, many respondents were uncertain of the dates they studied a particular curriculum while others, according to our records, reported dates incorrectly. Where more than one respondent was available from the same workshop, cross-checks were made concerning what the participants studied and when they studied it.

A second problem concerns the large number of non-respondents (48%) from our sample. Because a non-respondent's study was not conducted, it becomes a bit hazardous to generalize beyond our sample.

Conclusion

It is difficult to make any conclusive statements about the cost outcomes provided in Table 1. What does it mean to say that it costs NSF $1.30 for a teacher to participate in an NSF sponsored program for one hour? Perhaps the question that should be asked is "Is it worth $1.30 per hour to train a teacher?" Alternatively, "Is it worth this money to reach the teachers' students?" A partial answer to this question, perhaps, lies in whether or not this expenditure is helping to achieve NSF goals. What is $1.30 per hour buying? Are teachers and students receiving benefit from these programs? This issue will be discussed in the second part of this paper.

Another possible answer to this problem is perhaps contained in a comparison of various delivery systems. A comparison of this type is provided below.

Comparison of Delivery Systems

Cost effectiveness measures provide a meaningful basis for certain kinds of decisions. Cost comparisons can provide additional useful information. Table 2 (Welch and Willson, 1975) provides estimates of costs and effectiveness measures for five different delivery systems. Estimates for 1973-74 are provided for the four additional delivery systems. Estimates for 1972-73 are included for the Portal School simply because more information was available for that year. The reader who feels uncomfortable with this decision is urged to refer back to Table 1 to make additional comparisons.

Table 2

Delivery System Comparison

Criterion	Delivery System				
	Accessible Schools (Mississippi)	Off-Campus Centers (Notre Dame)	Collaborative (S.Dakota)	Portal School (Wyoming)	Summer Workshops (S.Dakota)
Number of Teachers	234	75	92	1906*	61
Estimated NSF Cost	$100,000	$115,126	$27,348	$88,030	$15,527
Hours of Instruction	45	90	38	32	80
NSF Cost Per Teacher Participation Hours	$9.50	$17.10	$7.80	$1.50	$3.20
Usage Rate***	84%	67%	96%	48%**	51%
Cost Per Pupil (adjusted) by Usage Rate	$6.20	$35.90	$14.10	$2.30**	$6.70

*This figure represents teacher semesters. The data indicate that approximately 13% of science teachers attended two workshops during the year.

**For science workshops only.

***Reported by participants during first year after training; recent research suggests these figures attenuate considerably in subsequent years.

PART II: ALTERNATIVE EFFECTIVENESS MEASURES

Introduction

A goal of NSF is to increase scientific literacy. Some of their efforts in this direction have taken the form of institutes for teachers. It is of interest to determine the cost of participation in these institutes; but this is not the complete story. It is also important to determine if these institutes are helping to accomplish the goals of NSF; it is important to determine if these institutes are having any differential effect on both the teachers attending and the students that these teachers affect.

Various NSF summer institutes were selected for study because data are available, both on program costs and effectiveness measures. First, institutes will be examined in terms of the effects on teachers participating in the institute and the corresponding costs. The second part will examine the effects on the secondary audience, the students, and the costs of resulting changes in various outcome measures.

Teacher Outcomes

Outcome measures for teachers were obtained during the course of "An Evaluation of Summer Institute Programs for Physics Teachers" (Welch and Walberg, 1968). Four summer institutes were randomly selected for study. Institutes were selected on the basis of the following criteria: 1) they were six weeks in duration, 2) they began on or after June 27, 1966, 3) they were designed for a single summer of study, and 4) they were designed specifically for physics teachers.

The directors of these four institutes agreed to administer a pre-post battery of instruments to the teachers attending the institutes. The instruments were administered on the first and last days of the institute.

The instruments are described below:

TOUS Test on Understanding Science. Designed to assess understanding of the scientific enterprise, scientists, and the aims of science. (Cooley and Klopfer, 1961).

SPI (Form T) Science Process Inventory. Developed to assess knowledge of the activities, assumptions, ethics, and products of science. (Welch and Pella, 1967-68).

TSTP Test on Selected Topics in Physics. Tests knowledge of physics but emphasized historical, philosophical and interdisciplinary items. (Selected Harvard Project Physics Test items).

One hundred and sixty-two persons began the program. Testing took place over two days and not all workshop attendees were present for all tests. We do know that at least 154 persons completed the courses. Where it was evident that persons from a particular institute missed a particular test, the mean for that institute was substituted for all statistics listed in Table 3. This seems more appropriate than substituting the grand mean because there were significant differences in gains among institutes. Eight persons still remain unaccounted for. It is not known by this researcher if these eight people ever completed the course.

Table 3 provides a cost-analysis for the summer institutes. Figures presented in the table have been rounded and the reader is again reminded that any recalculations based on these figures must take rounding error into consideration. The effectiveness measure used is cost per percentage point gain. Percentage point gain essentially means how many points the mean score was raised on an instrument compared with (i.e., divided by) how many points the mean could have increased up to a perfect score. The reader will note that three sets of cost figures are provided. This is for the benefit of

those who feel that the results should be generalized to 162 people or, for that matter, should remain confined to those who took the tests.

Total NSF costs for the four institutes were estimated at $166,130. It must be kept in mind when considering cost outcomes that these workshops were conducted several years ago. NSF financial policy decisions (e.g., reduction of stipends) along with economic conditions of the time (e.g., inflation) need to be taken into account when considering cost outcomes of any particular year.

It is obvious that these teachers are demonstrating significant gains on these measures. The problem to be pondered is whether it is worth $166,130 to raise 154 teachers three points on a test of physics achievement. Put differently, is it worth $58.50 to raise one teacher one percentage point on a test? Perhaps a partial answer to this question lies in whether or not students are receiving benefit from their teachers' attendance of these institutes.

Student Outcomes

It would seem from the previous analysis that these institutes have a positive effect on its attendees. The next logical step is to explore the effects, if any, that are transmitted to the students and the corresponding costs.

The program selected for study was the Harvard Project Physics summer institute held at Wellesly in 1967. Outcomes measures are available from the evaluation report, A National Experiment in Curriculum Evaluation (Welch and Walberg, 1972). Cost data was provided by the Harvard Project Physics staff and includes travel expenses, stipends, instructional costs*, and room, board, and incidental services provided by Wellesly. Total expenses were $58,837. Again, NSF policy changes and economic conditions must be taken into consideration when computing present or future cost outcomes.

*estimated

Table 3

Cost-Analysis of Teacher Outcomes*

Instrument	TOUS	TSTP	SPI (Form T)
Number Test Items	60	40	87
Number Examinees	147	153	151
Pre-test Mean (N=154)	44.07	23.33	71.77
Post-test Mean (N=154)	46.02	26.40	73.21
Possible Gain (N=154)	15.93	16.67	15.23
Actual Gain (N=154)	1.96	3.07	1.44
Average Percentage Gain (N=154)	12.3%	18.4%	9.4%
Cost/Percentage Point Gain (N=154)	$87.80	$58.50	$114.50
Cost/Percentage Point Gain (N=162)	$83.40	$55.60	$108.80
Cost/Percentage Point Gain (N = No. of Examinees)	$88.30	$59.00	$116.30

*Figures have been rounded

During the summer, a national random sample of 34 teachers was brought to Wellesly for a six-week training session on Project Physics, a physics course for high school students. The following year these teachers taught the course. A variety of instruments were administered in a pre-post format to these teachers' classes (N=1583) and to a control group (N=853). Three of these measures were chosen for analysis: Test on Understanding Science (TOUS), Science Process Inventory (SPI), and Physics Achievement Test (PAT). The latter is a locally developed test of general topics in physics (Winter & Welch, 1967).

Table 4 provides a cost-analysis of student outcomes with regard to the three instruments. The analysis is viewed in terms of cost per percentage point difference; that is, how much does it cost to raise one student's test score one percentage point above a control group's percentage point gain.

Again, it would seem that these institutes are having a positive effect on the secondary audience, the students of the teachers attending an institute. Those students show greater achievement than the control group. In some cases, this gain is small (SPI); in others (PAT, TOUS), the gain is greater. The type of question that still remains is whether it is worth $58,837 to raise 1583 students an average of 6.5 percentage points on a Test Of Understanding Science over and above students whose teachers had not attended institutes.

Conclusion

Obviously, I have a done a great deal of side-stepping with regard to making judgments of cost outcomes. In partial answer to whether it is cost-effective for teachers to participate in NSF sponsored institutes,

Table 4

Cost-Analysis of Student Gains

Instrument	TOUS	PAT	SPI
Number Test Items	60	40	135
Pre-test Mean (Experimental)	32.7	18.4	105.9
Post-test Mean (Experimental)	35.5	24.3	108.4
Possible Gain (Experimental)	27.3	21.6	29.1
Actual Gain (Experimental)	2.8	5.9	2.5
Percentage Points Gained (Experimental)	10.3%	27.3%	8.6%
Pre-test Mean (Control)	33.5	19.2	104.9
Post-test Mean (Control)	34.5	23.1	107.3
Possible Gain (Control)	26.5	20.8	30.1
Actual Gain (Control)	1.0	3.9	2.4
Percentage Points Gained (Control)	3.8%	18.8%	8.0%
Percentage Points Difference	6.5%	8.5%	.6%
Cost/Percentage Point Difference	$5.70	$4.40	$61.90

I have looked toward gains on various outcome measures. In partial answer to whether these teacher gains are cost-effective, I have raised the point as to whether students are receiving benefit. But given that both the teachers and the students are gaining on the measures discussed above, it still remains to be determined whether or not the gains are worth the costs.

It is not my purpose to make these judgments. I have neither the inclination nor qualifications to do so. The real purpose of this paper is twofold. First, I hope I have provided exploratory information that might be useful in future decision-making. Secondly, I hope I have stimulated interest in an aspect of evaluation that needs both further attention and exploration. Traditionally, evaluators have not been trained in cost-analysis. Neither are records kept in anticipation of such analyses. In 1969, Robert Stake had this to say about cost-analysis in educational evaluation: "It embarrasses me to admit that I know nothing about the measurement of costs." I hope this is changing and I have reason to believe it is. Recently, I have seen both pleas and models for cost-analyses appearing in the evaluation literature.

I would especially like to thank the staff of the SMTC and Harvard Project Physics, along with the Comprehensive Project Directors for their efforts and patience in assisting with this study and providing information.

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